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A Comparative Analysis of the Organizational Effectiveness of Three Korea Land and Housing Corporation Construction Field Groups

Jachoon Koo
University of Kentucky, JachoonKoo@uky.edu

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Jachoon Koo

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Advisor: Dr. Nick Petrovsky

MARTIN School of Public Policy & Administration

UNIVERSITY OF KENTUCKY

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Executive summary

The purpose of this study is to propose a performance evaluation method (organizational effectiveness value) that is most suitable for LH field organizations and to suggest an improvement plan by comparing and analyzing the results from organizational perspective.

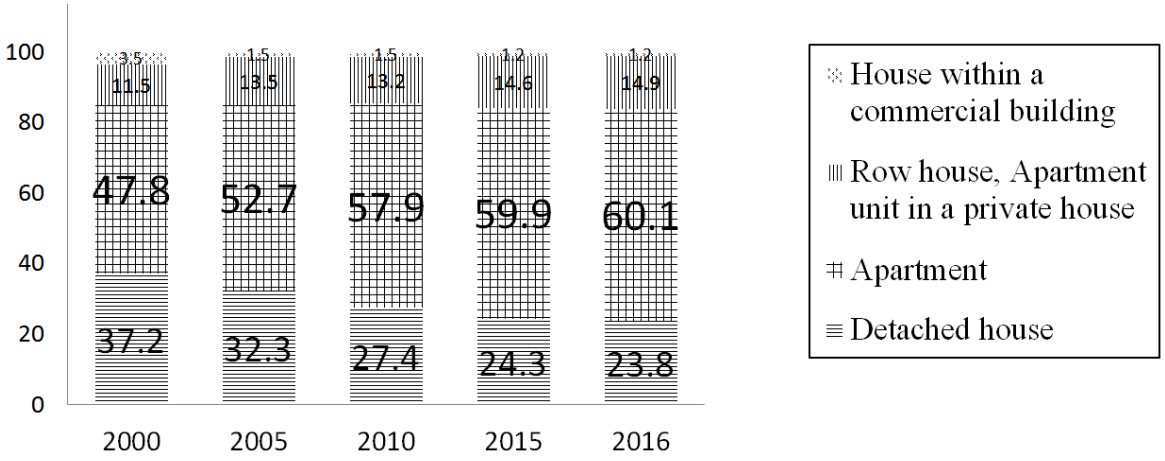
I compared and contrasted three LH construction fields. The following is my research findings: First, the main factors which determine successful or unsuccessful field are organizational cohesion and inter-organizational communication. Mutual communication of field groups affects the quality more, if the field conditions are difficult. Second, if field groups fail to cohere and communicate, it is likely to lead to low performance in cost management, construction management, and quality management.

In this study, I recommend that LH field organizations consider more organization effectiveness values and maintain harmony, coordination, diversity and balance with other field organizations. I suggest that LH should play a leading role in terms of organization management for the future.

1. Introduction

According to Statistics Korea, 60.1% of housing units in South Korea are apartments (See Figure1). The share of apartments has been steadily increasing. Korea Land and Housing Corporation (LH) plays a big role in supplying apartments. LH has built the largest number of apartments in Korea. LH has been contributing to the stabilization of the housing supply for Korean low to middle income families by providing 2.43 million housing units[1] since its foundation as Korea National Housing Corporation in 1962.

Figure 1. Change in housing types of South Korea by year



(Source: Statistics Korea, Complete Enumeration Results of the 2016 Population and Housing Census)

In 2017, LH is building 129,061 housing units across 168 residential construction projects, where numerous construction companies are participating in on-site units. LH is in a supervisory position, overseeing contractors in various construction types such as architecture,

[1] 1.18 million housing units for sale, 1.25 million rental housing units. 2.43 million housing unit is almost 13.4% of all housing units (18.13 million housing units) in Korea (LH brochure, 2013).

civil engineering, machinery, electricity. Cooperative relationships with contractors are very important, as it is necessary to integrate many processes to build flawless apartments efficiently.

However, there has been no research on LH construction projects to link the inter-organizational interactions or to suggest improvement of the field organization on the theoretical basis. The reason is that the field organization is temporary and it is made up of a community of groups dispatched from different organizations. Integrating them and resolving problems between the organizations is difficult. This is a recurring phenomenon at the organizational level, but many people have thought that this is a personal problem.

The framework and role of the organization in the field are very important to LH to cope with many changes in the construction industry. My research attempts to explore and study the organization itself in the field, away from existing researches which focus on technical and administrative field systems. This Capstone is important because it is rare to study the inter-organizational relationship in the construction fields.

2. Problem definition

LH is short of on-site supervisory personnel due to continuous expansion of business and differentiation of work. Most of the supervisory personnel are concurrently in charge of two or three fields which are away from each other. Contractors are also experiencing difficulties as revenue has decreased due to the stagnation of the construction market, and it is hard to hire technicians, which it leads to the increase of labor costs. Changes in labor law and the activation of labor unions are changing the environment of the construction industry to be less hierarchical. These trends are changing the organizations within the LH field.

A construction field is a collection of project organizations that are temporarily organized to build structures as contracted. It takes a few months from the beginning of a project for field organizations to have stable structures, and it is only about halfway through the construction period that the participating organizations establish mutual trust. LH, as a public organization, encourages contractors and supervises to check if their works satisfy the specifications.

LH is in the commanding position, and the constructors carry out the order. This relationship is often found in principal-agent relations. Here, the agent is typically under pressure because the supervisor is well aware of the problems that can occur in the field. These differences in positions often provoke distrust between supervisors and contractors in technical, administrative, and cost related matters. Inter organizational communication is interrupted, and in this process, difficulties and friction arise.

When performing a labor-intensive project in a construction field, there are many organizational conflicts since there are several companies with different interests. Those conflicts are mainly caused by the cost of construction. The three components of construction management are time, quality, and cost management. The relationships of these factors are 1) cost increases in the less time there is for a project, 2) quality increases as the cost increases, and 3) quality increases as the time allotted to a project increases. Generally, supervisors fix the construction period and cost, then concentrate on quality management. However, construction companies tend to focus on cost management to maximize their profits. So, they tend to neglect quality as much as supervisors will allow them.

3. Research purpose

The purpose of this study is to propose a performance evaluation method (organizational effectiveness value) that is most suitable for LH field organizations and to suggest an improvement plan by comparing and analyzing the results from organizational viewpoint.

4. Subjects

I compare and contrast LH construction fields. They are: Seongnam JD (JD), Jecheon GJ (GJ), and Chungju CD (CD). All have already been completed, allowing me to review all phases of each project. The main details of the three construction fields are as follows (see Table1).

Table 1. Construction Status

Status	JD	GJ	CD
Construction period	May 8, 2009 ~ Jun 6, 2012	Feb 19, 2014 ~ Sep 30, 2015	Jun 25, 2015.~Nov 12 2016
Total floor area	89,891M^2	17,325M^2	13,852M^2
Number of Buildings & households	11 APT buildings/ 545 households	2 APT buildings/ 268 households	3 APT buildings/ 296 households
Floors	13-21	15	5-8
Cost of construction	63,334,000,000 KRW ($55,073,043)	11,296,698,000 KRW ($9,823,216)	12,562,610,000 KRW ($10,924,001)
Contractor	Company L	Company D	Company S

5. Research scope

The scope of the study is limited to LH's on-field supervisory organization and main contractor organization (usually architecture, machinery, and civil engineering companies),

which plays a major role in construction management. In a LH construction field, more than 30 companies usually work together and one main construction company accounts for more than 70% of total construction cost. Therefore, the relationship between groups is also limited to the relationship between the main contractor and the supervisory organization of LH.

The field organizations that were formed in three fields are group level organizations dispatched from each head office. Because the field organization is based on the organizational design already implemented by the headquarters, the research takes place at the group level, not at the organizational level such as LH's headquarters and local branch, or contractors' headquarters.

6. Literature Review

In previous research, Lee & other (1997) was directly focused on the efficiency and performance of the construction field. They proposed a construction field evaluation model. By applying the model, all fields can be evaluated in terms of efficiency and performance. However, it should be reviewed according to the needs of each organization and situation. Based on this evaluation model, my research will find out the fit of task structure, performance norms, workforce composition and human relations applied as elements of organizational cohesion. In order to investigate the relationship between organizations, communication will be added to the level of organizational interaction. Next, as more quantitative data are needed to ensure objectivity, quantitative indicators will be added.

In order to examine the relationship between organizations, previous studies have shown that organizations form exchange mechanisms and inter-organizational linkages due to

interdependence (Jo and Lee, 2008). Ngidang (1993)(Jo and Lee, 2008, recite) suggested this system to be characterized by two basic interdependent structures: organizing and communicating. Then, the study extracted these elements as follows (See Table 2).

Table 2. Organizational Performance Influencing Factors

Non-interdependent factors (Organizational management factors)	**Interdependency factors**			
	1) Organizational perspective		**2) Communication perspective**	
	Resource organization	**Full systemization**	**Resource dependent**	**Group survival**
Trust, Public service, Motivation, Leadership, Organizational Structure, Institution, Organizational culture	Resource management, Program management, Personnel management	Relationship With community, Organizational Citizenship, Social capital	Linkage program (joint project), Information sharing (customer retention / program information), Materials support (funding, material support)	Interpretation and interaction between managers, documents of agreement among organizations

Source : Jo & Lee (2008). P234, The table is reorganized

Here, 'Organizational perspective' and 'Communication perspective' are handled separately in equal positions. Inter-organizational communication has been recognized as an important factor in improving organizational performance. If so, is it possible to judge that the organization's performance, such as quality improvement, has been improved by relatively unofficial factors such as inter-organizational communication? We can refer to the Hawthorne experiments of Roethlisberger and Dickson (1939)[2] as a basis for this. They concluded that socio-psychological conditions such as job motivation in humans, rather than physical work conditions such as intensity of light, may further affect production efficiency. In other words, they found that employees' organizational and job attitudes, human treatment of employees of

[2] Roethlisberger and Dickson (1939) investigated the effects of changes in physical working conditions, such as lighting, working hours and break, on productivity in Hawthorne workers at an electric company in the US in the late 1920s. They found that the productivity increased even when the lighting of the workshop was dimmed or the rest time was reduced. (Eun, 2013)

sympathetic and understanding supervisory organizations, and informal groups have more impact on production efficiency. This Capstone covers different organizations, but there are similarities of relationship between supervisory and employee. In addition, two components of the communication perspective; the content of indicators for resource dependence and group survival, are well suited to field organization. Therefore, one hypothesis that 'communication between field organizations affects quality' is established.

I refer to contractor evaluation of Lee and other (2017) to find out which factors are appropriate for evaluating. They treated construction management capability and organizational management capability as the owner's capacity assessment. This suggests that there is an additional need for organizational capacity building on the LH field, which focuses exclusively on management skills. I only refer to the factors (See table3), since the number of questionnaires collected is too small.

Table 3 Owner capability evaluation items

Construction Management Capability	**Organizational Management Capability**
Business, planning, Design, Process, Material, Contract, Cost, Information, Quality, Safety, Personnel, Financial, General	In-Organizational support and control system, Executive leadership, Education and training

(Source : Lee and other (2017). P149. The table is reorganized

Finally, I refer to a 'Framework of the comparative performance measurement in the construction industry' (Yu and others, 2004) about what to look for in order to evaluate the organizational effectiveness value. They set out performance indicators in terms of (1) financial, (2) customer, (3) internal work process, and (4) learning and growth. Among these indicators, items (3) and (4) are the most relevant indicators of organization. The main items are as follows (See Table 4).

Table 4. Measuring element

Measurement element	Factor	Contractor	Owner
(3) Internal process	Competitive factors	R & D investment amount, technology capacity	R & D investment amount, Technology capacity
	Business process	Accident rate, sales and general management rate, Processing speed	-
	Customer management	-	Market demand reflect level
	Operational efficiency	-	Achievement of business goal, Cost reduction performance, Sales and general management ratio Fund recovery rate, Accuracy of funding plan
(4) Learning growth	Organizational Capability	Contractor Excellent manpower ratio, employee turnover rate, Education and training costs, Knowledge sharing level, Employee productivity	Owner Excellent manpower ratio, Education and training costs, Knowledge sharing level Employee productivity

Source : Yu and others. (2004). P179-180. The table is reorganized

Taken together, the preceding research shows that the tendency of construction industry performance measurement takes into consideration various aspects without evaluating the present financial value alone. In particular, considering the public nature of LH, it is reasonable to quantify the organizational capacity by group cohesion and communication. It is better to evaluate a value concept considering cost management, construction management and quality management as existing researches.

7. Research questions

The research question of this study and the hypotheses for this question are as follows.

7.1 Question

What distinguishes successful public-private partnerships / contracts in apartment complex construction from unsuccessful ones?

7.2 Hypotheses

Hypothesis 1: The better the group cohesion of field organizations, the better the performance.

Hypothesis 2: The better the group communication of field organization, the better the performance.

8. Research Method

8.1 Items of organization evaluation

According to previous study (Lee and other, 1997), the effectiveness of a group can be measured by group cohesion and group performance. I added group communication (See Table5).

Table 5. Items for group evaluation

Group Cohesion (C*i*)	**Group Communication (I*i*)**	**Group Performance (P*i*)**
Task structure, Performance norms, Workforce composition	Proximity, Human-Interaction fairness, Integrity, Consultation and communication level	Cost management level, Construction management level Quality management level

8.2 Definition of indicators

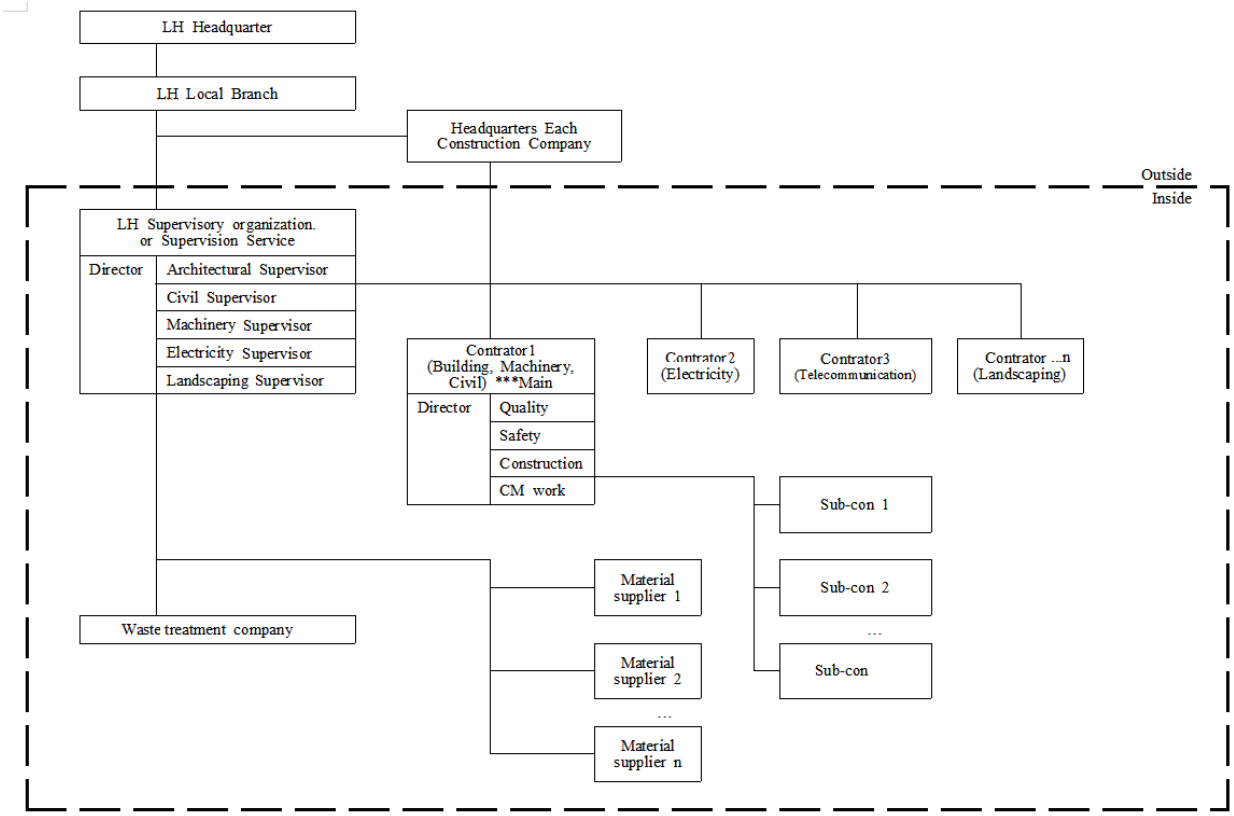
8.2.1 Group cohesion

The components of organizational cohesion in previous research (Lee & others, 1997), are qualitative and ambiguous. I adapted and enhanced them to fit the present situation of LH. First, organizational cohesion is divided into three categories: task structure, performance norms, and workforce composition. Eight measurement of indicators were selected. Task structure consisted of number of participating companies, the speed at which processes were completed, and percentage of full-time employees. Performance norms consisted of contractor's ranking, the contractors' technical staff retention, and defect repair rate. Workforce composition consisted of the persistence rate (1-turnover among all employees on a construction field) and technology workforce ratio.

Generally, a large number of groups are effective for large and complex constructions (ex, nuclear power plants, etc.), and a small number of groups are effective for simple and repetitive constructions. The latter is advantageous to LH apartments, because LH builds a fairly standardized apartment building. Nevertheless, the number of companies participating in one apartment project is increasing in Korea. Contracts are also becoming more diverse. Laws have been changed to require LH to directly purchase materials and to put them into the field in order to protect SMEs (Small and Medium Enterprises) in recent year. As a result, a large number of material companies have become involved. Now that there are too many companies involved in one field (See Figure2), coordination problems are getting worse.

Another obstacle to the task structure is process promotion. If the process is delayed, it can not keep up with the precedence and follow-up sequence, causing much confusion in the task. If too many participants are involved in a limited construction period, the task structure becomes more difficult. Therefore, the number of participating companies was given according to the degree of intensiveness and the degree of process completion was evaluated at the point at which

Figure 2. General organizations of LH construction field



80 percent of construction time[3] had been completed. Also, it is meaningful to review the structure of the main contractor, which is at the core of construction work. In the case of the CD field, the staffing of the field personnel was temporary, and frequent turnover during the construction caused difficulties due to vacancies in the work structure, especially for essential positions such as safety staff. Of course, in order for an organization to be able to perform its functions, there must be people to perform it. In reality, there may be frequent manpower replacement situations in the field, so, no matter how good organizational structure it is, it cannot perform its normal functions.

[3] At this time most processes should have been completed (up to installing furniture)

Second is the performance norms. The relationship between group cohesion and productivity depends on performance norms[4]. Although the quality standards are presented in the specifications, the performance norms tend to depend on qualitative aspects such as conversation methods and attitudes of employees. Therefore, performance norms were determined by questionnaire according to the degree of its clarity and uncertainty in the previous research (Lee & others, 1997). However, the method of this study is a quantitative measurement, so, the following three indicators were set as the measurement. First, if the level of contractors is called 'large corporations' in Korea, the selection process of employees is strict, and then excellent talent joins, and they show high group norms in a stable work environment and high standard of performance. This can be seen as a typical case of the company L of the SD field. Each year, the government announces the contractor's ranking of construction companies with the evaluation value of construction capability. This also includes the total number of technical personnel of construction companies. The number of technical personnel can be used to assess the status of technical departments and systematic manpower management. In addition, the speed of work that occupies an important part of the construction project needs to be seen. In the case of the defect repair rate measurement, it is necessary to systematically move the entire groups in a given time (within 1 month in most cases) to obtain a high maintenance rate (97% or more). It can be evaluated objectively by LH headquarters[5].

Third, it is constituent of human resources. Work experience was indexed in the previous study (Lee & others, 1997), but the higher the skill level of the members, the easier it

[4] It can be defined as the standard of action for how hard you work and how much you need to adjust the level of output. It is a standard action that must be kept in order to achieve the goal.

[5] In Korea, according to the relevant laws, people who will move into the apartment unit will visit the field in advance 30 days before moving in. Through this visit, they investigate their house unit, and point out the contents. LH Headquarters will check the repair rate after one month later and inform field of the score.

was to deal with the problem. As the field organization is a temporary organization, short-term technical cohesion is more effective than trust formation through mutual continuous work. Technological abilities that can handle the difficulties in the field will strengthen the learning ability of each other and the capacity of human resources will be influenced by the skillfulness of the leader groups.

8.2.2 Group communication

Group communication need to be examined at the horizontal and vertical levels. In addition, the promptness in communication and decision making is also an important factor. If the task is easy, mutual division of labor will be also simple, but if it is complicated, mutual cooperation needs to be activated and someone need to be in charge of presenting problem and solving by discussing with diverse groups. To measure the level of group communication, proximity of the field should be considered. If there is a LH supervisory office and a contractor office in the same field, a positive effect can be expected in communication because they can have lots of opportunities to contact immediately, but if the LH supervisor does not reside in the field, it would be hard to communicate frequently. In the case of GJ field, there were few opportunities for face-to-face meeting since it is 200km away from LH's branch office.

Secondly, the 'Integrity Assessment' conducted by the 'Auditing Department' of LH's headquarters can be used as a measurement tool. It yearly evaluates fields of LH and its three out of six questions are about the attitude of the supervisor, transparency and fairness of the work process. Indeed, the authoritarian attitude of supervisors in the field can cause the antagonism of participating companies even if there is no corruption, thus significantly lowering the integrity score.

Lastly, the contract execution rate is another important factor because securing appropriate profit by changing contract is very important for the contractors. It is not easy to change the cost or period of the contract because the supervisor cannot change the contract simply by the contractors' request. The supervisors are required to be conservative because they need to go through the screening of branch office and the LH's headquarters. It accompanies a lot of paper works to get an approval, so there must be constant formal or informal meetings and consultation between the staff to meet the requirements and to be approved. As the decision process is complex and there are various constraints, the time span for changing the contract can be an indicator to measure the level of cooperation. If the contract is changed in the first half of the process, the coordination at the field can be considered to be good. On the other hand, if most of the contract changes are made near the completion date, there must be some delay in the decision making. In this case, the contract changing would have caused the friction between the groups, and lead to difficulties in inter-relationship.

8.2.3 Group performance

The economic feasibility of group performance was measured by the total cost of construction management cost to the total construction cost. The cost of construction management is based on the cost per person for a year of LH's supervising staff. It was calculated as 0.5 person in case of working simultaneously in other fields, and 0.3 person in case of working in the regional branches at the same time for the estimation of the number of supervisors. In the case of the supervision service fields, LH staff's average annual salary was added to the annual supervision service cost.

The group performance of construction management was based on the evaluation score

of ‘Construction Management Department’ of LH headquarters. Objectivity is secured as the cases of integrity and defect repair rate.

To evaluate the quality of group performance, defect rate is used. The rate of defects is the total number of defects after completion when the residents inspected before they move each units. However, since the floor areas of the units are different, it is not possible to use the defects occurrence number. Therefore, the total number of defects was divided by the total floor areas of the apartment to compare.

8.3 Composition of indicators

The measurement items and indicators are as follows (See table 6).

Table 6. Composition of indicators

Item	Measurement index	Indicators	Contents
Cohesion	Task structure	Number of participating companies	The smaller the number of participants in a certain period, the more clearly the task structure.
		Timeliness of process completion	The better the process promotion, the more clearly the division of labor
		Percentage of full-time staff	Having a large percentage of full-time employees makes it easier to divide and integrate tasks.
	Performance norms	Contractor ranking	The higher the competence of the company, the better the group norms
		Number of contractor's technical staff	A high standard of performance for quality by securing technical personnel
		Defect repair rate	The higher the defect repair rate, the higher the norms for quality
	Workforce Composition	Persistence ratio (1-employee turnover)	The fewer changes in field technicians and supervisors, the better the workforce composition.
		Percentage of staff who are highest grade engineers[6]	The high technical ability of the field workforce makes construction easier and provides mutual learning opportunities
Communication	Contactability	Proximity	Physical proximity helps to form positive relationships by increasing contact opportunities
	Fairness, integrity	Integrity score	Improving communication, transparency, fairness, and openness can improve organizational relationships
	Negotiability, Cooperation Communication	Degree of contract changes	Communication facilitates the proper timing of contract changes
Performance	Cost management	Supervising cost	The cost of the construction management of the owner and supervision service cost
	Construction management	Construction management score	Construction management level
	Quality management	Defect rate	Quality management level

[6] In Korea, under the Construction technology Promotion Act, construction engineers are managed in four grades; Beginner, Intermediate, Advanced, and Highest

8.4 Evaluation of each indicator

For each of the 14 evaluation criteria, I obtained the distribution of values. Using the distribution, I defined the rating five level, poor to excellent. For the standard setting, by analyzing the relative distribution, I obtained data from LH's headquarters. The criteria for the evaluation of each indicator are as follows (See Table 7).

Table 7. Rating table[7]

No	Indicators	Rating Level				
		1 (Poor)	2 (Insufficient)	3 (Moderate)	4 (Good)	5 (Excellent)
1	Number of participating companies	2.5 or more	2.49 ~ 2	1.99 ~ 1.5	1.19 ~ 1	Less than 1
2	Timeliness of process completion	Less than 68%	68.1% ~ 72%	72.1% ~ 76%	76.1% ~ 80%	More than 80%
3	Percentage of full-time staff	Less than 60%	61% ~ 70%	71% ~ 80%	81% ~ 90%	More than 90%
4	Contractor ranking	Below 201th	200th ~ 101th	100th ~ 51th	50th ~ 11th	10th~ 1th
5	Number of contractor's technical staff	Less than 50	50 ~ 99	100 ~ 499	500 ~ 999	More than 1000
6	Defect repair rate	Less than 92%	92% ~ 94.4%	94.5% ~ 95.4%	95.5% ~ 96.4%	96.5% ~ 100%
7	Persistence ratio (1-employee turnover)	Less than 50%	51% ~ 60%	61% ~ 70%	71% ~ 80%	81% ~ 100%
8	Percentage of staff who are highest grade engineers	Less than 20%	21% ~ 30%	31% ~ 40%	41% ~ 50%	More than 50%
9	Proximity	More than 30Km	5Km ~ 30km	Within 5km but Impossible on foot	Accessible on foot	Together inside of field
10	Integrity score	Less than 9.05	9.05 ~ 9.324	9.325 ~ 9.574	9.575 ~ 9.824	9.825 ~ 10
11	Degree of contract changes	Less than 20%	21% ~ 30%	31% ~ 40%	41% ~ 50%	More than 50%
12	Supervising cost	More than 4%	3.1% ~ 4%	2.1% ~ 3%	1.1% ~ 2%	Within 1%
13	Construction management score	Less than 86.2	86.2 ~ 88.1	88.2 ~ 91.9	91 ~ 93.4	93.5 ~ 100
14	Defect rate	Less than0.1325	0.121 ~ 0.1325	0.09126 ~ 0.12	0.0776 ~ 0.09125	0.0775 or less

[7] Refer to Table A-1 of Appendix (p32-35) basis for the criteria for setting the interval of this table, In particular, regarding the range of 5 grades.

8.5 Grading

For each three fields, the results of measuring the grade according to the indicators are as follows. (See Table 8)

Table 8. Grading

No	Indicators	Measurement	Target field			
			JD	GJ	CD	Bench Mark
1	Number of participating companies	Total number of participating contractors / Total construction month	4	2	2	5
2	Timeliness of process completion	Cost payment rate of time pass at 80%	1	5	2	5
3	Percentage of full-time staff	Number of irregular employees / number of full-time employees	5	4	1	5
4	Contractor ranking	Construction contractor ranking	5	2	1	5
5	Number of contractor's technical staff	Number of technicians of contractor	5	2	1	5
6	Defect repair rate	Repair defect rate percentile	2	5	5	5
7	Persistence ratio (1-employee turnover)	Number of staff remained the same during the project / Total number of staff	4	4	2	5
8	Percentage of staff who are highest grade engineers	Number of highest grade technical staff / Total number of staff	1	3	5	5
9	Proximity	Distance between field groups (access method and time)	4	1	2	5
10	Integrity score	Integrity score percentile	2	4	4	5
11	Degree of contract changes	Number of contract changes at 80% of construction period/ Total number of change	1	4	1	5
12	Supervising cost	Supervision cost / Total cost	4	1	1	5
13	Construction management score	Construction Management evaluation score	1	3	1	5
14	Defect rate	Total number of defect occurrences / total floor area of apartment	3	5	2	5

8.6 Applying weights

The weights were determined by the AHP[8] (Analytic Hierarchy Process) method according to the category of the indicator.

Table 9. Weights

No	Indicators	weights	λ max[9]	C.I.[10]	λ max	C.I.
1	Number of participating companies	**0.33****	3.05400	0.02700	3.03267	0.01633
2	Timeliness of process completion	**0.07**				
3	Percentage of full-time staff	**0.26***				
4	Contractor ranking	**0.06**	3.09567	0.04783		
5	Number of contractor's technical staff	**0.001**				
6	Defect repair rate	**0.02**				
7	Persistence ratio (1-employee turnover)	**0.23***	-	-		
8	Percentage of staff who are highest grade Engineers	**0.04**				
9	Proximity	**0.49****	3.00899	0.00449	-	-
10	Integrity score	**0.07**				
11	Degree of contract changes	**0.44****				
12	Supervising cost	**0.06**	3.05433	0.02716	-	-
13	Construction management score	**0.16***				
14	Defect rate	**0.78*****				

*** Weights greater than 0.5, ** Weights greater than 0.3 and less than 0.5, * Weights greater than 0.1 and less than 0.3

[8] AHP is a structured multi-attitude decision method (Saman & others, 2013).The main advantage of AHP is its capability to check and reduce the inconsistency of expert judgment. This is a pairwise comparison of the indicators by a table of 9 intervals. Refer to Table A-2 of Appendix (p36) .

[9] λ max is maximum eigenvalue of the comparison matrix

[10] C.I (Consistency Index) = (λ max – n)/(n-1), as an indicator for verifying the logical contradiction in response, if it is less than 0.1, it means that it is compared with consistency.

9. Results

9.1 Score

The results of applying the weights to the grades (Grade score*Weight) are shown in the following table (See Table 10).

Table. 10 Grade score * Weight

Item	Measurement index	No	Indicators	Field			
				JD	GJ	CD	Benchmark
Cohesion	Task structure	1	Number of participating companies	1.32	0.66	0.66	1.65
		2	Timeliness of process completion	0.07	0.33	0.13	0.33
		3	Percentage of full-time staff	1.32	1.06	0.26	1.32
	Performance norms	4	Contractor ranking	0.29	0.11	0.06	0.29
		5	Number of contractor's technical staff	0.02	0.01	0.00	0.02
		6	Defect repair rate	0.03	0.08	0.08	0.08
	Workforce Composition	7	Persistence ratio (1-employee turnover)	0.90	0.90	0.45	1.13
		8	Percentage of staff who are highest grade engineers	0.04	0.11	0.18	0.18
	Total (1+2+3+4+5+6+7+8) Benchmark comparison value (%)			**3.99 (80%)**	**3.26 (65%)**	**1.83 (37%)**	**5 (100%)**
Communication	Contactability	9	Proximity	1.96	0.49	0.98	2.45
	Fairness, integrity	10	Integrity rating	0.14	0.28	0.28	0.35
	Negotiability, Coorporation, Communication	11	Degree of contract changes	0.44	1.76	0.44	2.20
	Total (9+10+11) Benchmark comparison value (%)			**2.54 (51%)**	**2.53 (51%)**	**1.7 (34%)**	**5 (100%)**
Performance	Performance of Cost management	12	Supervising cost	0.24	0.06	0.06	0.30
	Performance of construction management	13	Construction management score	0.16	0.48	0.16	0.80
	Performance of quality management	14	Defect rate	2.34	3.90	1.56	3.90
	Total (12+13+14) Benchmark comparison value (%)			**2.74 (55%)**	**4.44 (89%)**	**1.78 (36%)**	**5 (100%)**

9.2 Group cohesion, group communication, and performance comparison

The group cohesion was highest in JD field with 3.99 points out of 5 points, followed by GJ (3.26) and CD (1.83). In the group communication, there were 2.54 points in JD, 2.53 in GJ and 1.7 in CD. The performance results were in descending order: 4.44 in GJ, 2.74 in JD, and 1.78 in CD. The leaderboards are as follows (See Table11).

Table 11. Field groups score (vs Bench marking of all indicators earn 5 points)

Item	JD	GJ	CD
Group Cohesion	**0.80**	0.65	0.37
Group Communication	**0.51(.508)**	0.51**(.506)**	0.34
Performance	0.55	**0.89**	0.36

The performance result was the highest in GJ. In the case of JD, cohesion level was the highest among the three sites, but communication was somewhat low. In the case of CD, where both organizational cohesion and communication scores were low, group cohesion and communication seemed to influence performance. These results suggest that if group cohesion and communication are both low, performance will be also low.

However, if either of group cohesion and communication is good, the field can show better performance. Even though JD has strong organizational cohesion, it was not linked to performance, and GJ has done well despite the fact that they have kept the two factors at a medium level. The cause of these cases should be analyzed further. In case of JD, the sum of organizational cohesion and communication was higher than other fields, but the performance was poor compared to GJ. The biggest feature of JD is that the contractor L is a large company in Korea ranked 8th in construction industry. However, the communication score is similar to GJ. This means that organizational structure and communication are separate factors. Especially, in

the LH field, the larger the company, the more time is delayed due to the mutual fixed document system and their own decision making system. Such factors can be seen from the fact that the contract change is overdue and that there is a mutual distrust between them. JD's integrity score is lower.

In addition, the external environment that influenced these achievements is the construction conditions. Those were considerably more difficult than other fields. JD had an excessive slope forming six floors of underground parking lots.

From the viewpoint of construction conditions, company D of GJ was a relatively small and medium-sized company, but there was a good construction site for building an apartment complex. The third company S of CD was lacking in competence as a local small company and the construction conditions were too difficult due to the insufficient construction time. Construction conditions are given by project, site, and environmental conditions with each company. This difficulty can be overcome by organizational cohesion and communication.

9.3 Group effectiveness value model

Cost performance, management performance and quality performance were applied to evaluate the value of collective effectiveness. These three factors were used as relative comparison numbers for the score of benchmark (all 5 points). The cost value of the group (the first equation, V$i_{(cost)}$) is derived from the cohesion (Ci), inter-organizational communication interaction (Ii), and the result of cost performance(P$i_{(cost)}$). On the other hand, group effectiveness value (V$i_{(effect)}$) are evaluated as collective of Ci and Ii with the performance of cost, construction and quality management (P$i_{(effect)}$).

$$V_{i(cost)} = (C_i + I_i)/2 * P_{i(cost)} \quad \ldots\ldots\ldots (1)$$

$$V_{i(effect)} = (C_i + I_i)/2 * P_{i(effect)} \quad \ldots\ldots\ldots (2)$$

Here,

$V_{i(cost)}$ = Group cost value

$V_{i(effect)}$ = Group effectiveness value

C_i = Group cohesion

I_i = Group communication

P_i = Group performance

9.4 Result of model application

The results of model application are as follows (See Table 11).

Table 12. Evaluation results

Division	JD	GJ	CD
Group cost value …(1)	**0.81**	0.18	0.11
Group effectiveness value …(2)	0.60	**0.88**	0.16

First, JD is more than 4 times cost-effective than GJ, and 8 times more cost-effective than CD in the group cost value. Compared to this, the results of GJ and CD are very poor, which is caused by the implementation of supervisory service that replaces the shortage of LH's supervisory personnel. In other words, the service cost of over 1 billion KRW($901,063) paid by the supervisor is usually 4 to 8 times more expensive than the self-supervised field. Currently, there are 32 (19%) supervision service fields among 168 LH fields[11]. As problem of LH's lack of manpower has increased, the number of on-field supervision has decreased significantly. Since the supervisory service field is determined by the headquarters prior to the formation of the field

[11] Source from September 2017 LH Construction Status

organization, the increase expenses due to the burden of the supervisory service is inappropriate as an evaluation factor.

The cost value ranking changes when construction and quality management performance is taken into account. Considering the results of valuation based on quality, GJ is more than 1.5 times as good as JD.

Now the remaining question is that which of the two indicators is valid as a performance. The answer can be found in the common goal of the field organization. The common goal of LH field is to produce good quality apartments within a given period. The given period means construction process management and good quality means quality management.

These criteria are very important in the evaluation of public organizations such as LH. Cost reductions by low manpower deployment resulting from existing cost-performance-oriented field operations can adversely affect quality and increase avoiding supervisory work with heavy workloads. Therefore, it is more desirable to achieve optimal efficiency by quality orientation and organizational harmonization. In LH field, it should be evaluated as improvement direction of field organization for the future.

9.5 Discussion: 'Contingency Theory' as a useful guide for LH

A large academic literature fits with my finding about the need to consider a broader set of factors to achieve effectiveness in future construction fields. LH has established a very efficient and strong field operating system since 1962 but this is now out of date. 'Table 12' shows four different perspectives on organizations. LH currently is in the first dimension, which

is closed-rational organization theory. The view of field organization in first dimension is mechanical and closed. The theory is based on Taylor's scientific methodology, Weber's bureaucratic theory, and Fayol's management theory.

Table 13. Classification of major organizational theory and representative organizational theorist

		Perspectives on humans	
		Rational	Social
Organizational Perspective	Closed	1900-1930 Taylor (1991) Weber (1947) Feyol (1949) First Dimension	Second Dimension 1930-1960 Mayo (1945) Seiznick (1948) McGregor (1960)
	Open	Third Dimension 1960-1970 Chandler (1962) Lawrence & Lorsch (1967) Thompson (1967)	Fourth Dimension 1970~ March (1976) Weick (1997) Senge (1990)

(Source: W.R. Scott, Organizations: Rational, Natural, and Open Systems, p128, revised)

According to Chandler's theory of organizational growth and organizational structure, an organization initially started with a limited production and a centralized structure. In the case of LH, since the organization has a long history, it has been segmented, highly structured, and rigid. However, because the field organization is temporary and is different from the LH's organizational structure from the beginning, it has a disorganized organization tendency, so a suitable model should be sought. According to Lawrence and Lorsch's theory, LH should follow the proposition that the subordinate units should have a structure that adapts to the environment if each subordinate unit's organizational environment is different. LH's field organization so far has often been understood as a miniature of organization of the LH headquarters or local branches. However, the environment of construction industry is deteriorating for many reasons.

In particular, the fourth dimensional theories represent the final direction that the field organization of LH should aim for. Fourth dimensional theories emphasize the importance of activeness, mutual cooperation, openness, and democratic inquiry to create knowledge for the survival of an organization as an open-social organization theory. Currently, the reality surrounding LH is in the open-rational system, which is a third-upper limit dimension, but LH's field organization management is based on closed-rational view that does not yet reach the upper limit of first. Such management reduces site-to-site flexibility in cases where rules and regulations can not keep up with current contingencies and environmental changes. The rigid procedures of LH's supervisory organization and the preference of rule of dehumanization approach frustrate the contractors.

According to 'Contingency Theory', situations and organizational characteristics can respond positively to a variety of situations provided that conformity determines organizational effectiveness. 'Contingency Theory' focuses on organizational effectiveness as an objective result, suggesting that each organization facing various situations should have certain characteristics. This organizational theory again reminds us that when we measure organizational effectiveness values, good results could have been achieved if JD field had been more committed to communication and CD field had been more committed to cohesion.

The variables in this theory depend on the suitability of the situation and organization characteristics. When an organization places importance on achieving its goals, productivity, profit, and sales are the organizational effectiveness variables. When an organization places importance on process, job satisfaction, organizational commitment, quality of work, and turnover rate are important variables. It is time for LH to focus on the later one that regards field organization as an open system and focus on the development of technology, social peace,

environmental and legal changes, and the operation of the field organization to accommodate the uncertainties.

10. Research finding, conclusion, and suggestion

Based on the results of comparative analysis of the three construction fields, the following findings and conclusions can be drawn.

First, the main factors which determine successful or unsuccessful field are organizational cohesion and inter-organizational communication. The main finding of this study is that mutual communication affects the quality more if the field conditions are difficult.

Second, if field groups fail to cohere and communicate, it is likely to lead to low performance in all aspects of performance; cost management, construction management, and quality management. It was unquestionably revealed in the poor results of CD field.

By combining all these results, I recommend that LH field organizations consider more organization effectiveness values and maintain harmony, coordination, diversity and balance with other field organizations. I suggest that LH should play a leading role in terms of organization management for the future.

11. Limitations of Research

The purpose of this study is to establish indicators and models of group effectiveness value and apply it to the field. However, the some data, for example, construction management

evaluation, defect repair rate, and integrity evaluation, used to measure in the research are difficult to obtain. So those are limited to the LH field. The concept of generalization used in this Capstone is only applicable to other LH construction fields, not those outside LH.

References

Bolman, Lee G. and Terrence E. Deal. (2013). Reframing Organizations: Artistry, Choice, & Leadership. *Jossey-Bass press*

Choi&other. (2008). An Empirical Study on the Effect of Interorganizational Communication on Organizational Performance. *Korean Government Scholarship, Volume 42,* 229–252.

Cho, Yoon Hyung. (2014). The Effect of Interactional Justice on Innovative Behavior-The Moderate Role of Perceived Organizational Vision

Complete Enumeration Results of the 2016 Population and Housing Census. http://kostat.go.kr/portal/eng/pressReleases

Eun, jonghwan. (2013). Public and Private Organizations Comparative Analysis of Job Satisfaction- Focused on the effect of shortening the legal working hours.

Lee, Jae-seob and Lee, hyun-Soo (1997). A Method for Evaluating the Optimum Level of Construction Field Orgarization.

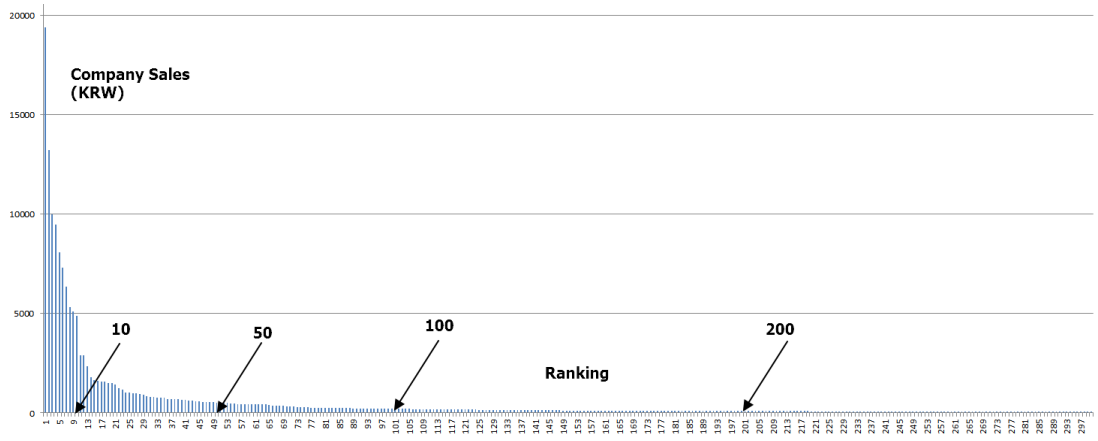
Lee, Siwook., Woo, Sungkwon., and Kim, Okki. (2017). A Study on Evaluation of Construction Project Owner's Organizational Competency, *Korean journal of construction engineering and management.*

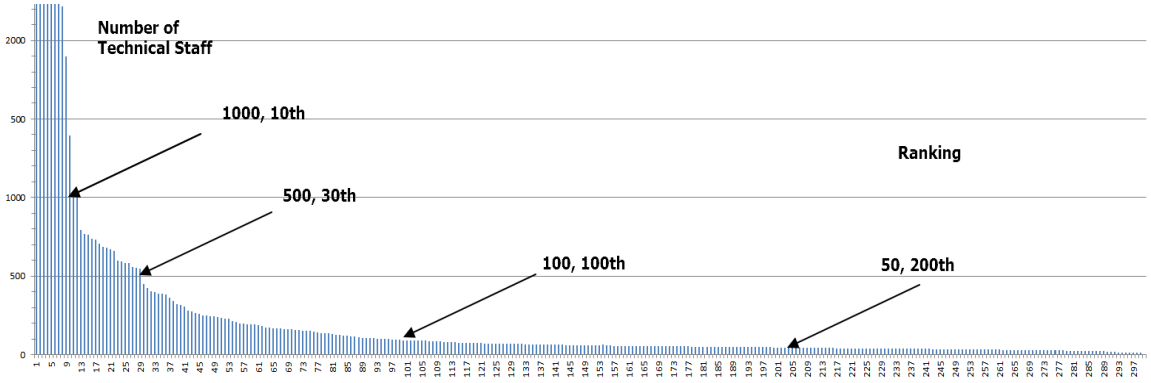
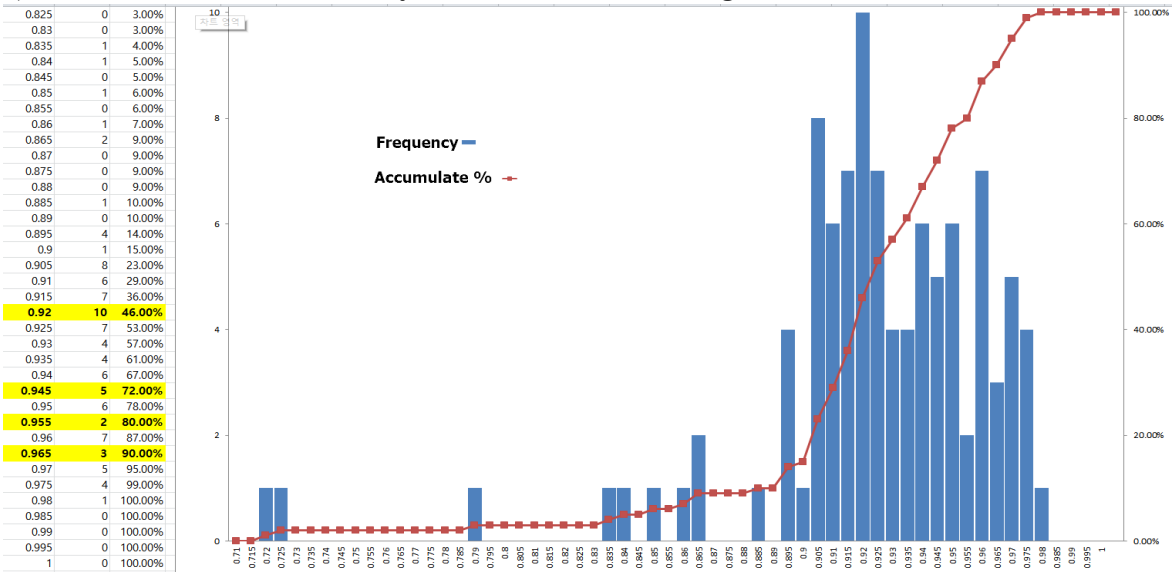
Saman Aminbakhsh, Murat Gunduz, Rifat Sonmez. (2013). Safety risk assessment using analytic hierarchy process(AHP) during planning and budgeting of construction projects, *Journal of Safety Research*

Yu, Il-Han., Kim, Kyung-Rai., Jung, Youngsoo., Chin, Sangyoon., and Kim, Yea-Sang. (2004). A Framework of the Comparable Performance Measurement in the Construction Industry. *Korean Institute of Construction Engineers*, *Vol 5 5th*(October)

Appendix

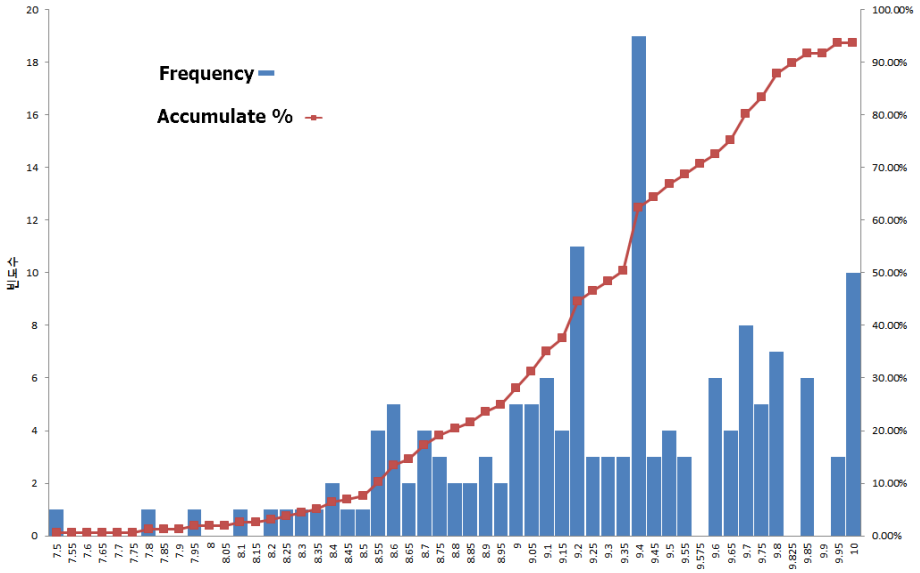
Table A-1. Rating basis

No	Basis for setting the grade interval
1	**1) Number of contractors** **2) Measurement: Total participating companies÷construction months** : The reason for dividing by the construction period is that as the number of companies in a certain construction period is getting bigger, there is a lot of coordination problems and inefficiency. 3) Benchmarking based on estimates of the minimum eligible participants and average construction period: 42companies/24months = 1.75 4) There are 5 general construction companies, 16 sub-cons, 17material suppler, 5 service contractors: 5+16+17+4=42 5) Source and data from 'Official Completion Document' of each field.
2	**1) Timeliness of process completion** **2) Measurement: Percentage of construction cost paid at 80% of time pass.** 3) The process of 80% of the time pass of construction is directly related to completion. 4) Base rate: Received 80% of construction cost at 80% time pass means excellent level because the construction cost is postpaid. Monthly payment of construction costs is general in LH. 5) The grade range was set by 4% gap from 80%, because 100%÷24month = 4.1%. As a usual 4% means one month of fast or late. 6) Source and data from 'Official Completion Document' of each field.
3	**1) Percentage of full-time staff** **2) Measurement: Number of full-time staff ÷Total staff** 3) Absolute value From 100% to 60% (10% gap) 4) Source and data from 'Official Completion Document' of each field.
4	**1) Contractor ranking** **2) Measurement: Ranking, Relative value according to distribution** 3) Sample number : 300 4) It has important meaning within 10th. It sharply decreases after 10th.  5) Source and data from Government announcement of year 2016.

5	**1) Number of technical staff of the contractor** **2) Measurement: Ranking, Relative value according to distribution** 3) Sample number : 300 4) It seems similar to the company rankings. The setting of the interval is a sharply decreasing from 10th.  3) Source and data from Government announcement of year 2016.
6	**1) Defect repair rate** **2) Measurement: Distribution analysis, Relative value according to distribution**  3) Sample number : 100 4) Based on the distribution of 100 scores of LH fields in 2016, Top 10% : more than 96.5% 10% ~ 20% : 95.5% ~ 96.5% 20% ~ 30% : 94.5% ~ 95.5% 30% ~ 50% : 92% ~ 94.5% Below 50% : Less than 92% 4) Source of 100 results of field from 'Rental Property Management Department' of head office
7	**1) Persistence ratio (1-staff turnover)** **2) Measurement: The number of field staff replaced or changed ÷ Total number of field staff** 3) Absolute value From 100% to 50% 4) Source and data from 'Official Completion Document' of each field.

8	**1) % of staff who are highest grade engineers** **2) Measurement: The number of field staff who has highest grade÷Total number of field staff** 2) Source and data from 'Official Completion Document' of each field.
9	**1) Proximity:** Physical proximity supervisor's office and contractors' office **2) Measurement:** Whether on-site, on foot, by car, or on business trip (over 30km).
10	**1) Integrity Score** **2) Measurement: Distribution analysis, Relative value according to distribution** 3) Sample number : 100 4) Based on the distribution of 157 scores of 2012~2016 5) Distribution analysis

8.5	1	7.64%
8.55	4	10.19%
8.6	5	13.38%
8.65	2	14.65%
8.7	4	17.20%
8.75	3	19.11%
8.8	2	20.38%
8.85	2	21.66%
8.9	3	23.57%
8.95	2	24.84%
9	5	28.03%
9.05	**5**	**31.21%**
9.1	6	35.03%
9.15	4	37.58%
9.2	11	44.59%
9.25	3	46.50%
9.3	3	48.41%
9.35	**3**	**50.32%**
9.4	19	62.42%
9.45	3	64.33%
9.5	4	66.88%
9.55	3	68.79%
9.575	**0**	**0.70701**
9.6	6	72.61%
9.65	4	75.16%
9.7	8	80.25%
9.75	5	83.44%
9.8	7	87.90%
9.825	**0**	**0.89809**
9.85	6	91.72%
9.9	0	91.72%
9.95	3	93.63%
10	10	93.63%
		100.00%



Top 10% : more than 9.825
10% ~30% : 9.575 ~ 9.825
30% ~50% : 9.35 ~ 9.575
50% ~70% : 9.05 ~ 9.35
Below 70% : Less than 9.05

6) Source from Headquarters Audit Department's Integrity Survey Report of 2012, 2015 and 2016.

11	**1) Degree of Contract changes (cost overruns)** **2) Measurement: The number of contract changes completed at 80% of construction time÷The total number of contract changes**. 3) Absolute value From 0% to 50% 4) Normally more than 1 change at 80% time pass 5) Source and data from 'Official Completion Document' of each field.
12	**1) Supervising cost ratio** **2) Measurement: Supervision cost÷Total construction cost**. 2) Usually more than 1 billion KRW need to 2 years 3) Source and data from 'Official Completion Document' of each field.

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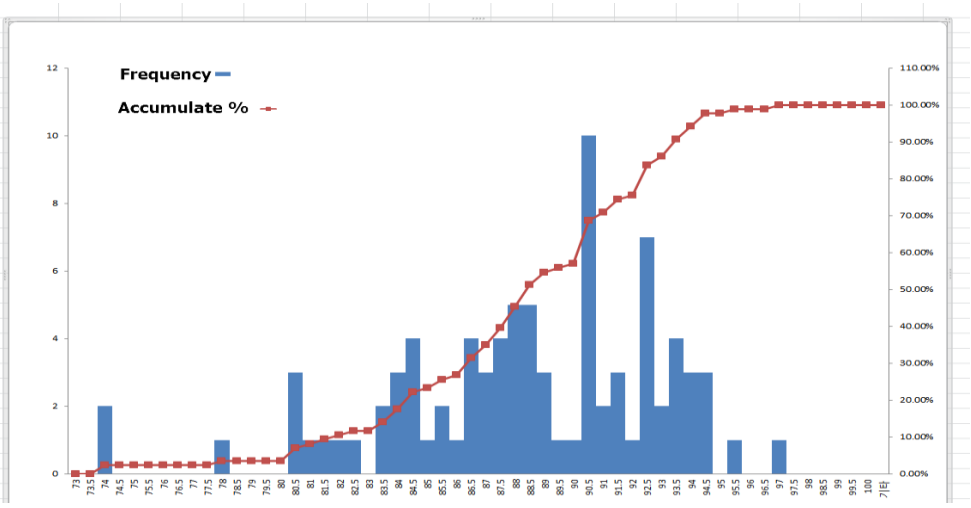
1) Construction management evaluation score

2) Measurement: Distribution analysis, Relative value according to distribution

3) Sample number : 86

83.5	2	13.95%
84	3	17.44%
84.5	4	22.09%
85	1	23.26%
85.5	2	25.58%
86	1	26.74%
86.5	**4**	**31.40%**
87	3	34.88%
87.5	4	39.53%
88	5	45.35%
88.5	**5**	**51.16%**
89	3	54.65%
89.5	1	55.81%
90	1	56.98%
90.5	10	68.60%
91	**2**	**70.93%**
91.5	3	74.42%
92	1	75.58%
92.5	7	83.72%
93	2	86.05%
93.5	**4**	**90.70%**
94	3	94.19%
94.5	3	97.67%
95	0	97.67%
95.5	1	98.84%
96	0	98.84%
96.5	0	98.84%
97	1	100.00%
97.5	0	100.00%
98	0	100.00%
98.5	0	100.00%
99	0	100.00%
99.5	0	100.00%



3) Based on the distribution of 86 scores of 2016,

Top 10% : more than 93.5

10% ~ 30% : 91 ~ 93.5

30% ~ 50% : 88.2 ~ 93.5

50% ~ 70% : 86.2 ~ 88.2

Below 70% : Less than 86.2

4) Source and data from Evaluation report of head office construction management department

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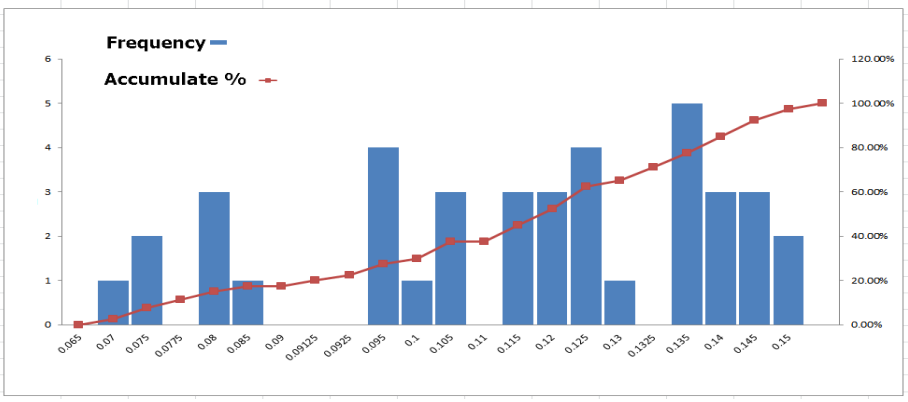
1) Defect rate = Total number of defects÷Total floor area of apartment(M^2)

2) Measurement: Distribution analysis, Relative value according to distribution

3) Sample number : 40

Classes	Frequency	Accumulate%
0.065	0	0.00%
0.07	1	2.50%
0.075	2	7.50%
0.0775	**0**	**11.25%**
0.08	3	15.00%
0.085	1	17.50%
0.09	0	17.50%
0.09125	**0**	**20.00%**
0.0925	0	22.50%
0.095	4	27.50%
0.1	**1**	**30.00%**
0.105	3	37.50%
0.11	0	37.50%
0.115	3	45.00%
0.12	**3**	**52.50%**
0.125	4	62.50%
0.13	1	65.00%
0.1325	**0**	**71.25%**
0.135	5	77.50%
0.14	3	85.00%
0.145	3	92.50%
0.15	2	97.50%
		100.00%



4) Based on the distribution of 40 fields' total number of defects from Assessment of rental property management department of head office

Top 10% : Less than 0.0775

10% ~ 20% : 0.0775 ~ 0.09125

20% ~ 50% : 0.09125 ~ 0.12

50% ~ 70% : 0.12% ~ 0.1325

Below 70% : Less than 0.1325

5) Data of floor area from Official completion documents and data of total number of the three field from preliminary inspection of customers.

Table A-2. AHP input data

Indicators	Left item is more important(<-), Relative importance (0 = equal), Right item is more important(->)																			Indicators
Number of participating companies	9	8	7	**V**	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Process propulsion rate
Number of participating companies	9	8	7	6	5	4	3	2	**V**	0	1	2	3	4	5	6	7	8	9	Percentage of full-time employees
Process propulsion rate	9	8	7	6	5	4	**V**	2	1	0	1	2	3	4	5	6	7	8	9	Percentage of full-time employees
Contractor ranking	9	**V**	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Contractor technical staff retention
Contractor ranking	9	8	7	6	**V**	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Defect repair rate
Contractor technical staff retention	9	8	7	6	5	4	3	2	1	0	1	2	3	**V**	5	6	7	8	9	Defect repair rate
Persistence ratio of employees	9	8	7	**V**	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Technology workforce Ratio
Task structure	9	8	**V**	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Performance norm
Task structure	9	8	7	6	5	4	**V**	2	1	0	1	2	3	4	5	6	7	8	9	Workforce composition
Performance norms	9	8	7	6	5	4	3	2	1	0	1	2	3	**V**	5	6	7	8	9	Workforce composition
Proximity	9	**V**	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	Integrity rating
Proximity	9	8	7	6	5	4	3	2	1	0	**V**	2	3	4	5	6	7	8	9	Contract change promotion rate
Integrity rating	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	**V**	7	8	9	Contract change promotion rate
Supervising cost	9	8	7	6	5	4	3	2	1	0	1	2	**V**	4	5	6	7	8	9	Construction management score
Supervising cost	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	**V**	Defect rate
Construction management score	9	8	7	6	5	4	3	2	1	0	1	2	3	4	5	**V**	7	8	9	Defect rate

Table A-3. Application data

Indicators	Three Fields data			Rating Level				
	JD	GJ	CD	Poor	Insufficient	Moderate	Good	Excellent
Number of participating companies	1.08	2.13	2.31		GJ/CD		JD	
Process propulsion rate	65	82	71	JD	CD			GJ
Percentage of full-time employees	100	80	33	CD			GJ	JD
Contractor ranking	8	112	256	CD	GJ			JD
Contractor technical staff retention	1896	93	25	CD	GJ			JD
Defect repair rate	92.13	96.95	96.84		JD			GJ
Persistence ratio of employees	74	74	55		CD		JD/GJ	
Technology workforce Ratio	15	37	55	JD		GJ		CD
Proximity	10	120	300	GJ	CD		JD	
Integrity rating	9.19	9.63	9.71		JD		CD	
Contract change promotion rate	17%	43%	0%	JD/CD				GJ
Supervising cost	1.78%	11.10%	9.29%	GJ/CD			JD	
Construction management score	85.9	88.26	80.52	JD/CD		GJ		
Defect rate	0.098	0.074	0.120		CD	JD		GJ

Table A-4. Basic data of three fields

Item	JD	GJ	CD
Block		A4BL	B5BL
City	Seongnam	Jacheon	Chungju
Type	General sale apartment	National rental housing	Happy house
Total floor area(㎡)	99,158	14,783	13,844
Number of Buildings	10	2	3
Total units	636	268	296
Floors	16-18	15	7-8
Construction period	May 2009~Jun 2012	Feb 2014~Sep 2015	Jun 2015~Nov 2016
Total construction period (days)	1,125	588	515
Total construction period (months)	37	19	17
Final cost of construction	91,105	11,297	14,987
Bid dropping (%)	78.46	70.03	80.51
CM cost (Supervision service cost)	0	996	1167
Supervision cost (LH)	1,623	258	226
Total cost of supervision	1,623	1,254	1,393
Total cost of supervision/Final cost of construction	1.78%	11.10%	9.29%
Total Contractor Labor Cost	5,680	963.93	844.26
Total Contractor Labor Cost/Final cost of construction	6.23%	8.53%	5.63%
Supplied materials cost		2,838	2,643
Number of field workforce of construction company	22	10	10
Number of field workforce of CM company	0	9	7
Number of field workforce of supervision company	5.5	1.7	1.7
Number of Total management personnel	27.5	20.7	18.7
Number of Total supervisory personnel	5.5	10.7	8.7
Initial cost of construction	71,714	11,432	12,031
Number of Alteration of contract	18	7	2
Extension of construction period (Day)	48	0	9
Total input of field workforce	157,946	20304	21,937
Total input of field equipment	6,807	105	4,710
Number of major contractors	2	5	5
Number of Sub-con	35	16	16
Number of Supplied materials	0	17	14
Number of waste companies	3	3	4
Total Participation Contractor	40	41	39
Total number of defects	5631	1076	1,549
Total Apartment Floor Area	57,679	14,611	12,897
Total number of defects/Total Apartment Floor Area	0.098	0.074	0.120
Defect repair rate score	92.13	96.95	96.84
Ranking of contracts	8	112	256
Estimated construction capacity	5,310	194	80
Total number of technical staff	1896	93	25
Integrity rating score	9.19	9.63	9.71
Construction management score	85.9	88.26	80.52